as rosewood, some as black as ebony, while others have a lighter color. Species of *Casuarina* also yield hard wood of various colors, some looking like oak already fumed.

The hardness and weight of *Eucalyptus* timbers are due to the predominance of thick-walled fibers. In some of the extremely hard woods of the genus the vessels are almost entirely blocked by tyloses. The figure in the wood is not due to large rays, as in oaks, but to the fact that fibers and wood elements run in waves. In color, this single genus furnishes perfect imitations of maple, locust, cherry, mahogany, and rosewood; while the timber, as hard and strong as any of these, takes a magnificent polish.

The taxonomic sequence follows that of BENTHAM and HOOKER. In each case there is a systematic diagnosis, with geographical range, and a description of the timber and its uses. Local names are given in addition to the scientific names. The rank in a scale of hardness and the weight per cubic foot are also given, and some of this information is summed up in a table according to hardness: extremely hard, very hard, hard, and moderate. In most cases photomicrographs illustrate transverse, longitudinal radial, and longitudinal tangential sections, which not only show the structure but also indicate the strength, hardness, and weight of the wood.

An unusual feature is a table of combustibility. Since wood in Australia is used to a considerable extent in railroad bridges and in shipbuilding, resistance to fire is a very desirable quality. By means of a "xylopyre" the time required to burn up a piece of wood of a definite size was determined with great accuracy. These tests show that many of the Australian woods are remarkably resistant to fire. In this quality *Eucalyptus Fletcheri* easily heads the list, with 19 minutes required to burn the test piece; next comes *Syncarpia laurifolia*, with 12 minutes; then *Casuarina torulosa*, with 8 minutes; followed by many species of *Eucalyptus* ranging from 7 minutes down to 3 minutes. The significance is evident when we note that in the same test our *Pseudotsuga Douglasii* has a time limit of 4 minutes, *Quercus alba* 3 minutes, *Juglans* sp., *Fagus sylvatica*, and *Sequoia sempervirens* less than 3 minutes.

A striking feature of the work, and one most likely to give it immediate practical importance, is a series of 126 magnificent plates in color, illustrating the natural appearance of the wood. These plates, together with the photographs of various articles, inside furnishings, buildings, etc., prove the variety and value of the Australian hardwoods.

The timely warnings, calling attention to the desirability of sane lumbering methods and the necessity for reforestation, should be heeded while the timber supply is still abundant.—C. J. CHAMBERLAIN.

NOTES FOR STUDENTS

Form and growth of trees.—In 1913 the Schnyder von Wartensee Foundation opened a prize competition of three years' duration "to stimulate new investigations upon the growth in thickness of trees." First prizes subsequently were awarded to ARNOLD ENGLER and PAUL JACCARD, professors in the Federal Polytechnical School in Zurich.

ENGLER[3] concerns himself with the effects of geotropic and heliotropic stimuli upon the form and structure of arborescent plants. He is of the opinion that old stout stems and branches of dicotyledons may develop marked geotropic and heliotropic curvatures, but considers that, in the case of the Coniferae, heliotropic bending is confined to the younger, more pliable portions of the stem. He devotes considerable attention to the study of the form and growth of broad-leaved trees on steep slopes, and concludes that the terminal shoots, particularly during the earlier stages in the ontogenetic development of the trees, tend to bend downhill toward more intensive illumination upon that side. During subsequent growth these curvatures are more or less completely neutralized by bending in the opposite direction in response to geotropic stimuli. His numerous stem analyses show that trees growing on steep slopes may be eccentric on the uphill side, the downhill side, or vary in their eccentricity at succeeding heights in the stem. Accelerated growth upon the uphill side is assumed to be due to geotropic stimuli, regardless of whether the stem is concave or convex, and eccentricity on the downhill side, as in Coniferae, to longitudinal compression upon the cambial layer. He reaches similar conclusions in regard to the eccentricities of stems and branches of trees growing upon level ground. In other words, accelerated growth upon the upper sides of stems or branches is geotropic, whereas that upon the under sides is due to longitudinal compression. The geotropic stimulus ceases to act only when the terminal shoot occupies a vertical position. Different parts of a tree may react differently toward light and gravitational forces. Thus in the younger (higher) portions of a stem heliotropic frequently overshadow geotropic stimuli, so that geotropic curvature and eccentricity are confined to the base of the stem. In dicotyledons the influence of gravity usually exceeds that of longitudinal compression, and accelerated growth of the under sides of stems and branches is found only where it is not inhibited by negative geotropism. Lateral eccentricity occurs when these two factors, working in opposition, neutralize each other. Longitudinal compression affects the volume of secondary xylem but not its structure. In ring-porous dicotyledons, "geotropic wood" is characterized by wider vessels and a greater proportion of summer wood; but in diffuse porous species, the wood of the upper and lower sides of stems and branches is of the same general type.

As evidence in favor of these views, ENGLER cites the crooked or curved stems of trees growing under peculiar environmental conditions; for example, on steep slopes, displaced from the normal vertical position, in unilateral

[3] Tropismen und exzentrisches Dickenwachstum der Bäume; Ein Beitrag zur Physiologie und Morphologie der Holzgewächse. Schr. Stift. Schnyder von Wartensee Zürich **21**:1–106. *figs. 1–30*. 1918.

illumination, etc.; such data as may be secured by critical field observations, detailed stem analyses, and a careful study of the past environmental history of the plants. Thus the method of attacking the problem consists in showing that variations in form are closely correlated in each case with variations in illumination, gravitational, or mechanical forces. Since it places a premium upon circumstantial evidence and deductive reasoning, its ultimate success is dependent upon the number of concordant facts that can be advanced in its favor. Although ENGLER's data indicate that bending actually occurs in old stems, they do not demonstrate in all cases that the curvatures are due necessarily to particular stimuli. For example, in tall dense forests, the sudden curvatures of trees toward gaps made by thinnings may be heliotropic; but it is also conceivable that they may be due to a lack of rigidity in tall (13–18 m.) very slender (8–13 cm.) trees. The reviewer has seen thinnings in lodgepole pine forests in which the crowns of tall unsupported trees have bent over until they touched the ground. Furthermore, if bending occurs in response to heliotropic stimuli and is produced by the activity of living cells (parenchyma) in the sapwood, as ENGLER supposes, the structure of the stem must be considerably modified. No conclusive evidence is presented to indicate that such modifications actually have taken place.

In the second of the prize essays, JACCARD[4] attacks the problem of the form and growth of trees from an entirely different angle. The first twelve chapters of his memoir are devoted to a criticism of the SCHWENDENER-METZGER hypothesis, which holds that the form of trees is determined largely by mechanical factors (wind and gravity), and to an exposition of his own theory that the "clear length" of the stem is, at successive heights, a shaft of equal water-conducting capacity. Inasmuch as this portion of the memoir is largely a recapitulation of former papers, which have been reviewed by GROSSENBACHER[5] and others, it may be passed over without further comment. The three succeeding chapters (pp. 101–169) are concerned with interesting experiments, designed to test the effects of mechanical, geotropic, and heliotropic stimuli and various types of girdling upon the form and anatomical structure of conifers and dicotyledons. A large number of young stems and branches were subjected to various types of flexure (sustained or intermittent). Their subsequent growth, form, and structure were found to vary, depending upon the intensity and duration of the stimuli. Thus if the stem of an erect conifer is bent alternately to the north and south, no "redwood" is formed unless the stem is allowed to remain in each posture for a certain period

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[4] JACCARD, PAUL, Nouvelles recherches sur l'accroissement en épaisseur des arbres: Essai d'une théorie physiologique de leur croissance concentrique et excentrique. Pub. Foundation Schnyder von Wartensee Zürich **23**: i–xii+1–200. *pls. 1–32. figs. 1–75.* 1919.

[5] GROSSENBACHER, J. G., The periodicity and distribution of radial growth in trees and their relation to the development of "annual" rings. Trans. Wis. Acad. Sci. **18**: part 1. 1915.

of time. Again, a slight curvature may accelerate the growth on the upper side of a dicotyledonous stem, whereas a more pronounced bend may produce eccentricity upon the under side or inhibit the growth of both the upper and under sides and lead to lateral eccentricity.

In the fifth and concluding section of the volume, JACCARD elaborates the following hypothesis: "The morphological characters common to all trees are determined (1) by the polarity of their organs, that is to say, by their tendency to grow most rapidly in a vertical direction, and (2) by the modifications which the exigencies of nutrition and the action of external forces (gravity, heat, light) impress upon this polarity. These modifications manifest themselves through the osmotic force of cells which engenders, on the one hand, two circulatory currents (the ascending sap and descending current of elaborated substances), and, on the other hand, mechanical strains and stresses (pressure of turgescence) capable of influencing the form of cells. . . . . In general, such variations in gross form and anatomical structure, as may be observed at different levels in the concentric, vertical axes of trees, are determined by the physical conditions of the transpiration stream and the flow of elaborated sap. On the contrary, the anatomical differentiation and variations in transverse sections, which are concomitants of the eccentric growth of inclined or horizontal branches, are due to mechanical forces engendered by the unequally rapid growth of the antagonistic sides of these organs, under the asymmetrical influence of gravity and light."

Although the author is justified in contending that the problem of the growth and form of stems and branches should be attacked from the point of view of fundamental physiological phenomena, and in rejecting teleological conclusions as unscientific, he extends his own generalizations much farther than is warranted by his experimental data. When one considers how little is actually known about the "ascent of sap," the growth and activities of the cambium and its derivative tissues, the distribution of food substances and osmotic pressures, and, in general, concerning transpiration, metabolism, and translocation and their interactivities in arborescent plants, one is inclined to question whether there are available at present sufficient reliable data to form the basis for such a comprehensive hypothesis as is formulated by the author.—I. W. BAILEY.

Factors of fruitfulness.—A contribution by WIGGINS[6] covers investigations for 5 years, chiefly upon trees that were 8 years old at the beginning of the experiment in 1913. Attention was centered upon the individual fruiting branch "in an effort to determine the effect of certain conditions and practices upon the development and performance of the individual fruit spur."

The data for the performance of the individual spurs were obtained from 8-year-old Rome, Gano, Winesap, Grimes, York, and Jonathan. The first selection was made of fruiting spurs, but after that a blossoming spur was

[6] WIGGINS, C. C., Mo. Exp. Sta. Research Bull. no. 32. 1–60. 1918.